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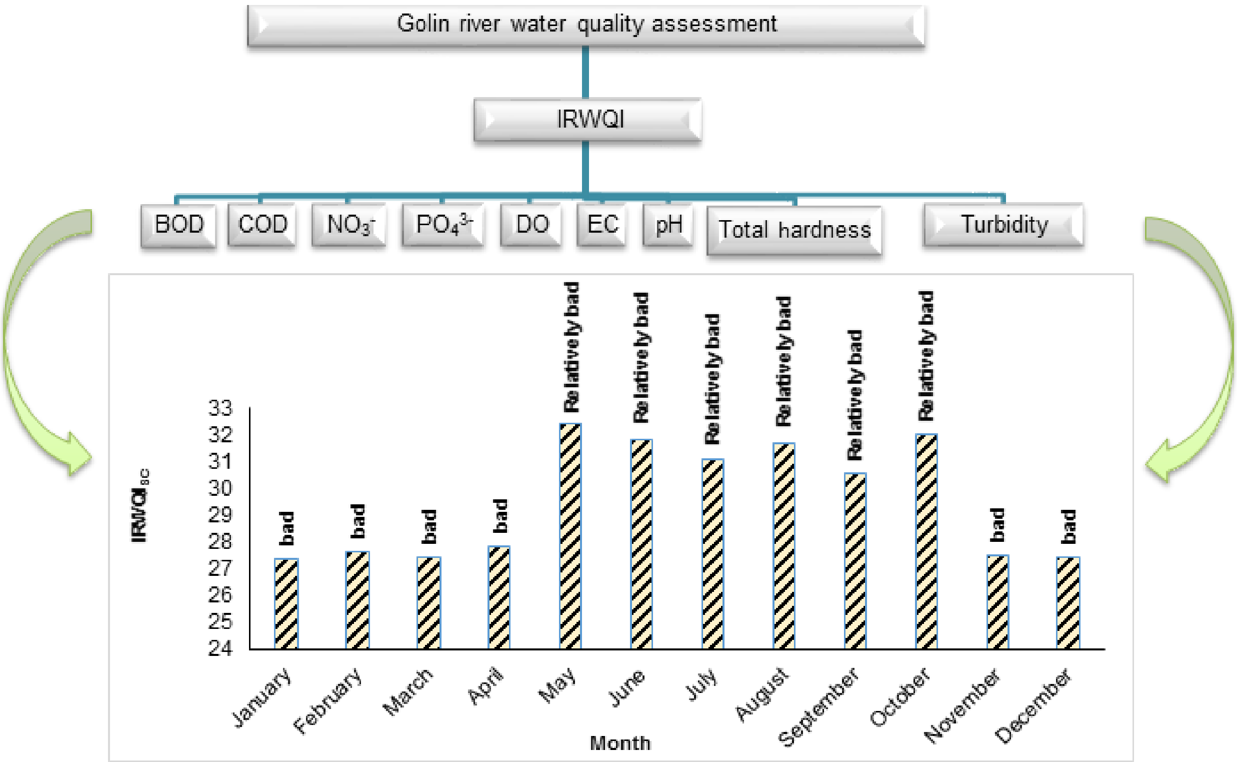
Evaluation of Golin river quality in Kermanshah province using the standard surface water resources quality index of Iran (IRWQISC)

Houshang Ghamarnia*, **Zoleikha Palash**, **Meisam Palash**

Department of Water Resources Engineering, Faculty of Agricultural Science and Engineering, Razi University, Kermanshah, Iran.

GRAPHICAL ABSTRACT



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ABSTRACT

Surface water quality management is very important. Qualitative indicators of water pollution can indicate the trend of quality changes over time and place. The aim of this study was to evaluate the quality of Golin river using $IRWQI_{SC}$ index. For this purpose, the Golin river water was sampled twice a month in a period of one year from May 2019 to April 2020 in Najar village station located in downstream of river. Different parameters which evaluated in this study were DO, pH, BOD_5, COD, nitrate, phosphate, electrical conductivity, total hardness and turbidity. The results of the study using the $IRWQI_{SC}$ index showed that the range of the index values in the warm months of the year was "between" 30.57 to 32.17 with relatively poor-quality category. While in the cold months of the year the index values obtained "between" 27.36 to 27.83 with poor quality category. In general, according to the results from the annual average of the $IRWQI_{SC}$ index, the numerical value was obtained as equal to 29.62, which showed Golin river in poor quality category. The results which presented in this study can be useful for different organization decision to perform their water related projects on Golin river.

1. Introduction

Water is one of the most important elements of the ecosystem and also rivers are of the most important water resources to meet the agricultural, industrial and welfare. In the recent years, the problem of water shortage in developing countries has increased. Numerous factors are important in the study of surface and groundwater quality, including physical, chemical and biological parameters. Although,

*Corresponding author Email: hghamarnia@razi.ac.ir

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water quality was classified by Horton in 1965. The special problem of water quality assessment consist of the large number of variables which to be measured (Boyacioglu. 2006). Increasing populations and various sources of pollution such as discharge of municipal, industrial and agricultural wastewaters as well as surface runoff have led to the spread of pollution limited water resources (Enrique et al. 2007; Samadi et al. 2009). In today's society, it has been proven that the source of many diseases are due to poor water quality (Naseri. 2018). In order to study the water quality in the shortest possible time, a tool should be used to determine the level of pollution with acceptable accuracy (Mirzaei, Abbasi, and Sakizadeh, 2017). Water quality indicators are methods that express water quality and can be used to evaluate changes in water quality over time and space and to identify and manage areas that are most threatened by pollution. By the mentioned indicators, a large amount of information obtained from water quality assessments is express as a dimensionless number that this number has an interpreted quality concept and definition on a graded scale (Jafari Salim et al. 2009). Due to the special role of water in human life, several environmental indicators have been presented by various organizations and institutions, including (NSFWQ), (IRWQISC), (WQI), and (OWQI). Meanwhile, Iran Water Resources Quality Index (IRWQISC) is a new index presented by researchers of the Environmental Protection Organization of Iran. This index classifies water quality status into seven categories by examining eleven parameters (The Iranian Department of Environment. 2011). Extensive studies were then conducted using water quality indicators, including the following studies. Tavakoli, Mohammadi Roozbehani, and Sobhan Ardakani (2015) studied the water quality of Aligudarz using two NSFWQI and IRWQIsc methods. The results showed that the IRWQIsc index performed better than the NSFWQI. Alizadeh, Mirzaei, and Kia (2017) using NSFWQI, IRWQIsc and WQI index to study the water quality of Karaj and Kan rivers by sampling from 20 stations from October 1991 to June 1992. The NSFWQI index rated the water quality of the rivers under study as poor to moderate, the IRWQIsc index rated them as very poor to relatively good quality, and finally the WQI index rated the quality of the rivers as good quality. Chabuk et al. (2020) analyzed the water quality of the Tigris River in Iraq using the Water Quality Index (WQI) and GIS software. They sampled from 14 stations along the river. The results showed that the water quality of the Tigris River downstream has decreased sharply. In a study, the water quality of the Indian Cigarette Wetland was evaluated monthly using the NSFWQI index for one year. According to the results, the water of the Ron Sigar pond was in the average range in terms of quality (Vaheedunnisha and Sandeep 2013). Jalilzadeh Yengejeh, Morshedi, and Yazdizadeh (2014) by examining and zoning the biochemical oxygen demand (BOD) of Dez River by GIS software stated that the average maximum and minimum amount of BOD during the average of six months were 150.83 and 3.16 mg/L, respectively. Based on the research results in the water quality study of Qarasu River, the results showed that this river has no restrictions for irrigating agricultural fields (Fatemi. 2015). Effendi and Vardiatno (2015) examined the quality status of the Chimbilawing River in Indonesia using the NSFWQI index and the pollution index (PI). The results showed that the NSFWQI index was in the range of 78-88 and the pollution index was in the range of -78.56 and in general the water quality of this river was in the good range. The results of study of water quality of Al-Gharafah river by WQI index for aquatic protection and irrigation showed that the water quality of the river was in the range of 38 to 39 (Ewaid. 2016). In a study, the water quality of the Bayan River in China was measured using the Water Quality Index (WQI). During the study, sampling was done along the river and various parameters were analyzed in the period of January 2017 to 2018. Based on the results, the average values of WQI in winter, spring, summer and autumn were 88.15, 71.70, 87.92 and 90.12 respectively, which indicated the good water quality for this river (Wu et al. 2020). The results of the study of Saod et al. (2020) for evaluation of spatial and temporal changes of the variable water quality index (WQI) on the Euphrates river in Anbar province of Iraq, showed that the water quality index of this river was between 43.33 to 55.10 and compared to the results of studies as has been done before, Euphrates river water quality decreased due to human activities in the region. The quality of Pasikhan River located in the north of Gilan province was evaluated using the NSFWQI index and based on the results, the water quality values of the stations in different seasons varied from 46 to 70. Based on results, Pasikhan water quality was in the middle quality category (Omidi and Shariati 2021). The water quality of the Haraz River was investigated by (Aminirad et al. 2021). Based on the results which published in this study, as the elevation decreased, the water quality decreased as well, and only in upstream areas (near the Poloor village and before the Chelav station), water quality was in the average condition, but near the Caspian Sea, the condition of Haraz River was worrying due to the existence of contamination sources.The water quality of the Pangonchi river was investigated by (Sajid Shahriar and Moniruzzaman 2022). Based on the results, the water of the river in terms of NSFWQI index was in the range of 53.43-55. 87 and was descriptively in the middle category. The results of water quality assessment using WQI index in two rivers of Tanzania also showed that water quality in Pangani river was in good range and in Zigi river was in polluted range (Mihale. 2022).

Due to tropical climatic conditions of Golin region and increase of water shortage in the recent years, which has increased the need for water and because a dam that called Zagros Dam has been constructed from the water of river and the water of this dam transfer as a canal with a length of 1800 meters to the Kork Strait Dam in Gilan-e-Gharb for irrigation of agricultural lands. So, measuring the water quality of the Golin river is very important Therefore, the present study was conducted to investigate the temporal changes of water quality in the station located downstream of Najar Golin village during of four different seasons. So, in this study, qualitative studies on the Golin river was reviewed and evaluated based on the IRWQIsc (Iranian water quality index), which accurately assesses the water quality status by considering various parameters.

2. Materials and methods

2.1. Study area

The important river in this study area is the, which consists of two main tributaries. These branches originate from Kamarzard, Skozan and Kafaravar mountains and flow in the southeast to northwest direction and then join the Alvand from the drainage of Deira plain near Darblut. In terms of climate in the heights of this city, winters are cold and snowy and summers are cold. In the low-lying areas near the Iraqi border, the climate is hot and dry. Because of this climate diversity, it has fertile soil and abundant water. This area have garden with different tree species and has a pleasant climate and lush nature as shown in Fig.1. The studied river is located in Golin, 33 km from Sarpol-e Zahab, Gilan-e-Gharb road in Kermanshah province. The Golin river basin is located in the geographical coordinates of 45° 60' to 45°44' east longitude and 34° 26' to 34° 9' north latitude and 3450 m above sea level (Fig. 2). The Zagros dam has been constructed on the Golin river which its water transferred by an irrigation and drainage networks to farmers' irrigation lands.

Fig. 1. Nature of Golin area.

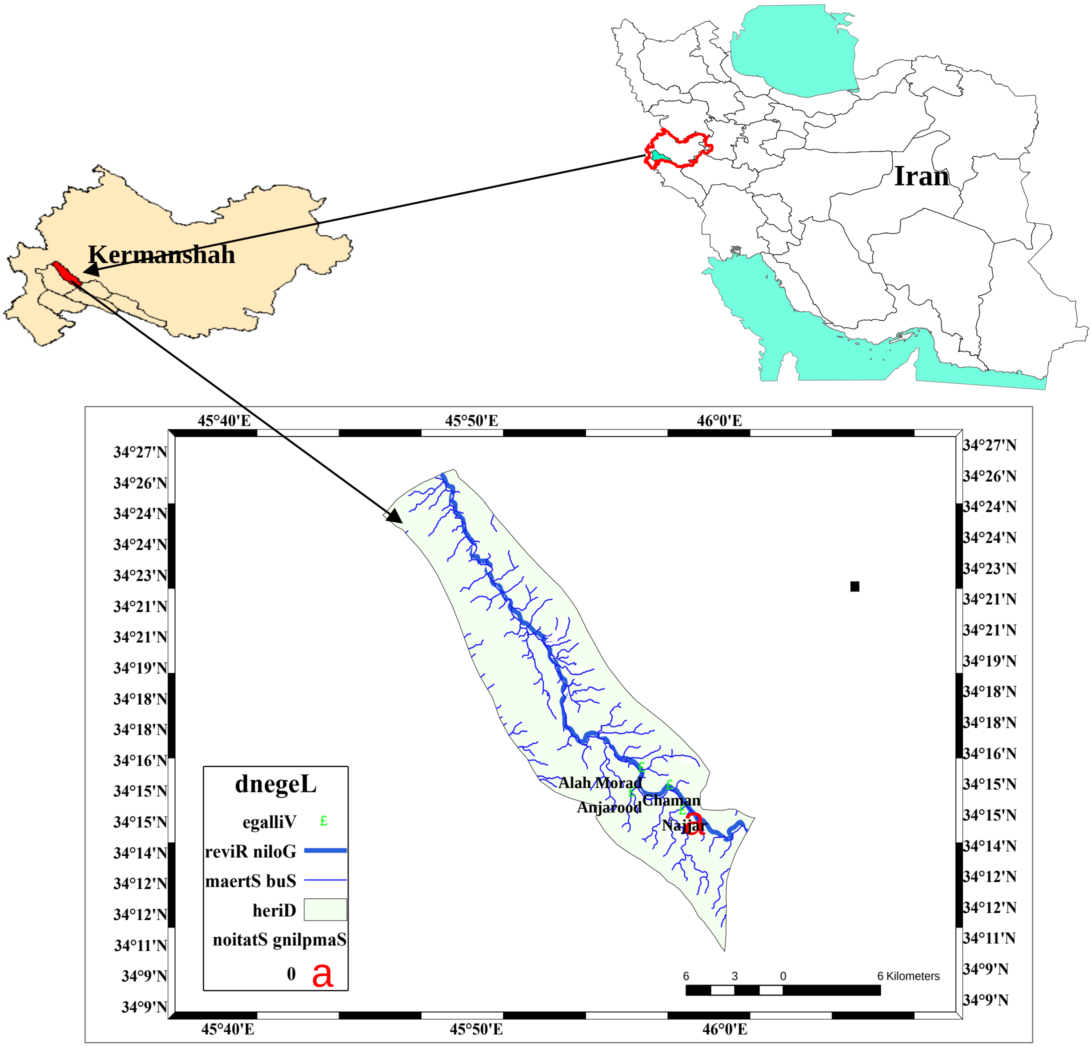

Fig. 2. Location of the study area, Golin River, Golin Sub Stream and sampling station.

2.2. Sampling period and the position of station

The sampling station was located on the Golin River downstream of the village of Najjar Golin with the geographical coordinate position of latitude 34°14' 27" N and longitude 45°58' 57 " N (Fig.3). Upstream of the sampling station are the villages of Chaman Golin, Anjarud and Golin allah Morad, and the choice of this place as a sampling station to assess the quality of water downstream of the river. Different parameters including BOD_5, COD, NO_3^-, PO_4^{3-}, DO, EC, pH, Total Hardness, Turbidity were sampled from the mentioned river water during the years 2019-2020.

(a)

(b)

Fig. 3. (a) Satellite map of location of sampling station that indicated by an arrow, and (b) Golin River sampling site.

2.3. Introduction of the IRWQISC index

Iranian Water Quality Index for Surface Water (IRWQISC) is one of the common indicators of surface water quality and introduced with the aim of using methods appropriate to the natural conditions and problems of Iranian resources. The IRWQISC index uses 11 parameters, which are presented in Table 1. This index is obtained according to Eq. 1 and is in fact the geometric weight average of the parameters representing the pollution. In Eq. 1, n is the number of parameters, Ii is he index value for the i-th parameter of the ranking curve (Fig.3). Wi is the weight of the i-th parameter Which is obtained from Table 4. ɣ is also obtained from Eq. 2.

$$IRWQI_{SC} = \left[\prod_{i=1}^{n} Ii^{wi}\right]^{\frac{1}{\gamma}} \qquad (1)$$

$$\gamma = \sum_{i=1}^{n} W_i \tag{2}$$

If the number of measured parameters is less than eleven parameters listed in Table 1, Eq. 1 is still usable and no correction is required. In this method, according to the value reported for each parameter, its numerical value is obtained from the graph as in Fig. 4. Then, by multiplying the numerical value of the parameter by the weight determined in Table 4, the final value of the index for each of the 11 parameters is obtained. Finally, the index value related to the studied parameters obtained from Eq. 1 determines the final number of water quality value. And using Table 2, the quality status of the studied water is determined.

2.4. Statistical analysis of data

In this study, SAS Ver 9.4 software was used to statistically analyze the data and check their normality. One-Way ANOVA was used to compare the effect of time conditions at the sampling station on the water quality parameters of the Golin River. Also, the means were compared to Duncan's test at the level of 0.05 %.

Table 1. Traits studied and final weight factor in $IRWQI_{SC}$ index

Parameter	Unit	Weight factor
Fecal coliform	MPN/100mL	0.14
BOD_5	mg/L	0.117
NO_3^-	mg/L	0.108
DO	%sat	0.097
EC	mho/cmμ	0.096
COD	mg/L	0. 093
NH_4	mg/L	0.090
PO_4^{3-}	mg/L	0.087
Turbidity	NTU	0.062
Total hardness	mg/L	0.059
pH	-	0.051

Table 2. Segmentation of IRWQISC index according to parameters

Color	Interpretive equivalent	Numerical values
Red	Bad	15-29.9
Orange	Relatively bad	30-44.9
Yellow	Medium	45-55
Green	Fair	55.1-70
Indigo	Good	70.1-85
Blue	Excellent	85>

Table 3. Results of monthly measurement of Golin River water quality parameters.

Station	Month	BOD, mg/L	COD, mg/L	NO_3, mg/L	PO_4^{3}, mg/L	DO, mg/L	EC, μS/cm	pH	TH	Turbidity, NTU
Najjar	Apr	4.80	11.0	2.445	0.11	98.80	1078.0	7.90	230.0	2
	May	1.60	10.0	0.942	0.27	91.0	980.0	7.40	195.0	10
	Jun	6.60	8.0	1.30	0.35	90.0	999.0	7.60	165.0	18
	Jul	4.0	2.0	1.388	2.20	89.50	934.0	7.70	190.0	4
	Aug	4.50	0.0	0.808	0.55	85.50	911.0	7.60	185	10
	Sept	3.50	25.0	1.606	2.10	92.25	922.0	7.80	205.0	8
	Oct	4.0	20.0	1.07	0.47	94.0	1116.0	7.90	210.0	2
	Nov	6.80	18.0	1.938	0.34	95.97	1048.0	7.90	220.	6
	Dec	7.80	18.0	2.265	0.12	99.95	1259.0	7.85	250.0	2
	Jan	8.60	14.0	2.929	0.54	103.1	1071.0	8.05	195.0	8
	Feb	7.60	6.0	2.650	0.23	100.05	1046.0	8.15	195.0	300
	Mar	8.20	18.0	2.285	0.40	93.30	1018.0	8.15	220.0	52
Annual average		6.04	12.08	1.830	0.64	94.45	1042.0	7.83	206.7	35.16

3. Results and discussion

The BOD_5 measured in many months was higher than the desired level due to the presence of high organic matter in the river water, which enters the river through livestock waste and human wastewater. As shown in Table 3, the values of those above mentioned parameters in the Golin river showed that the parameters of BOD_5 and COD in April, November, December, January, February, and March were in an increasing trend. One of the factors involved in increasing the value of those parameter was the entry of agricultural effluents due to the increase in agricultural operations in the mentioned months Moghadam (2017). According to Fig.5, another reason for the high BOD_5 content was the washing of dishes and clothes along the river, which has led to the entry of detergents and eventually water pollution. Our results were agreed with increasing of BOD_5 and COD parameters for Khorasan and Bagherabad rivers because of entering wastewater and agricultural runoff as reported by Abbaspour, Javid, and Habibi (2013).

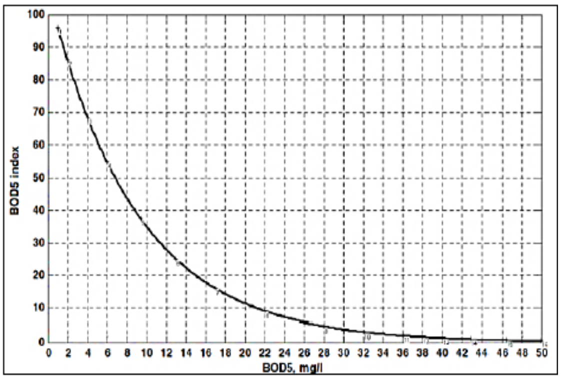

Fig. 4 .Diagram used for parameter evaluation - BOD_5.

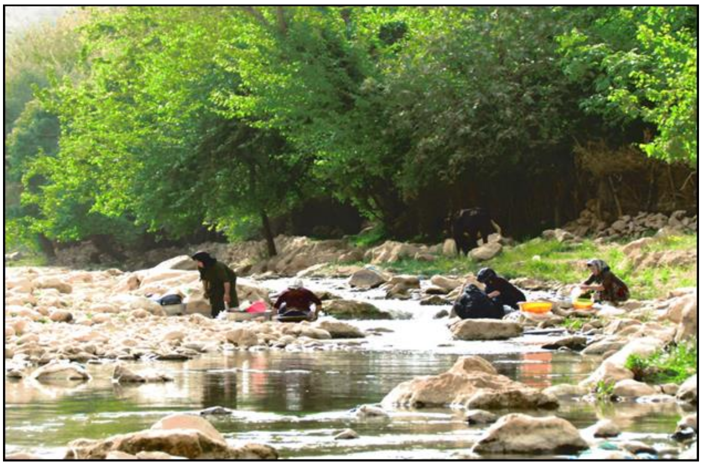

Fig. 5. Washing dishes and clothes on river, which causes entry detergent

The results of nitrate content in Golin river during one year showed that the highest numerical values were observed in April, November, December, January, February, and March (Fig.5). Due to the negative effect of high values of the mentioned parameter on water quality, we can see a decrease in Golin river water quality. Excessive use of chemical fertilizers in agriculture caused the entry of excess nitrate into the river water and as a result of increasing agricultural activity in November and December and fertilizing operations caused an increasing trend of nitrate in the water. Ghorbanpour and Karimi (2017) also reported that the use of chemical fertilizers was the reason of Ashmak River in Kuchesfahan to be exposed to physical and chemical pollution. Which is in line with the results of the present study.

The level of water acidity was affected by various factors such as the amount of suspended solids, colloidal materials, organic matter, and the presence of halogenated anions and the direction of agricultural runoff in the water. According to Fig.6 the high pH level in February and March was due to the phenomenon of otrification in the Golin River. In the atrophic phenomenon, the rate of photosynthesis is higher than metabolic activity. Which is characterized by intensification of algal accumulation. Increasing photosynthesis phenomenon leads to more consumption of bicarbonate, as a result of the pH increases (Kargar. 2004). Also according the Fig. 6 the lowest value of pH was observed in May and the reason can be explained by the flow of agricultural runoff into the river and the entry of contaminants with acidic base.

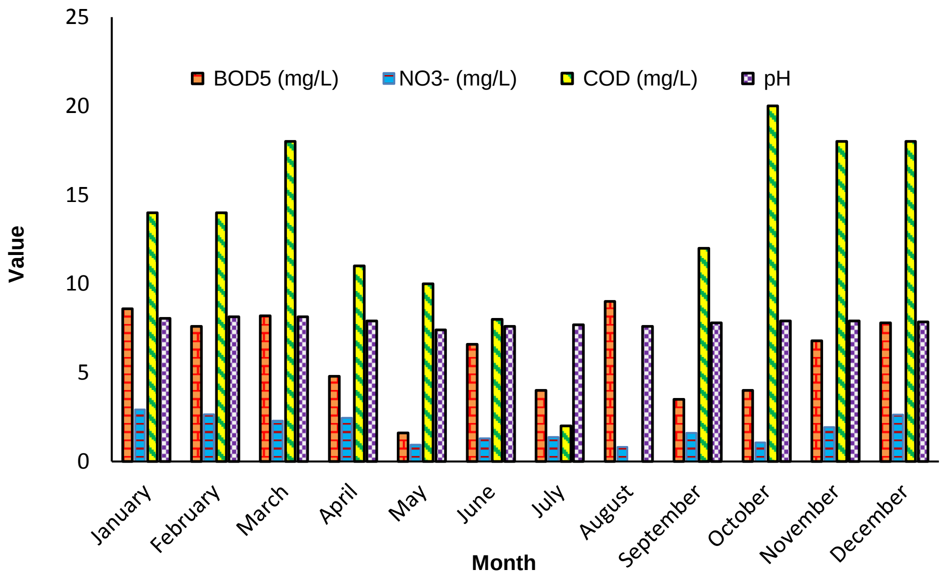

Fig. 6. The values of measured parameters in different months.

Saturated oxygen index (DO) was affected by different factors such as: the ability of oxygen gas to dissolve in water, the partial pressure of oxygen gas in air, temperature and purity of water (Eqbali Shams Abad. 2010). As shown in the Fig. 7 the trend of water solution oxygen changes in the sampling station decreased during the year from May to August. This value reached to its minimum value of 85.50 % saturation in August, which was a downward trend as a result of decreasing rainfall and consequently increasing the salt values in the water. Due to the replacement of solutes with molecular oxygen and by increasing temperature and microorganisms' activities, the value of oxygen consumption increased, which leads to a decrease in dissolved oxygen. According to the river water quality standard, the value of dissolved oxygen in the Golin river water was within the standard range in all months of the year.

In the annual review of the electrical conductivity (EC) parameter, the results showed a decreasing trend of this parameter from February to September (Fig. 7). However, the value of electrical conductivity in the Golin River reached a maximum in October and December, which can be attributed to agricultural activities and dissolution of salts in the Golin river water. According to the reports of the World Health Organization (WHO. 2004) and Khalaji et al. (2017), the high level of electrical conductivity due to natural weather factors, sedimentary rocks and agricultural activities was consistent with the results of the present project.

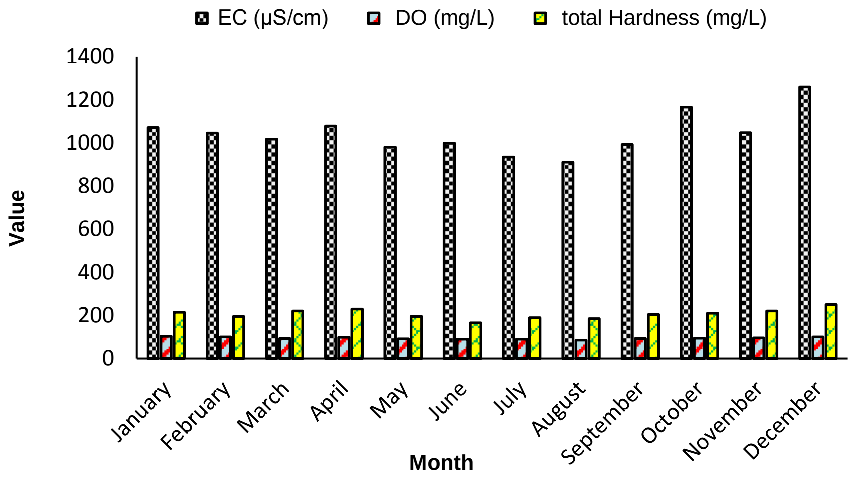

Fig. 7. The values of measured parameters in different months.

The highest total of hardness (TH) parameter with 250 mg/L in December and the lowest of this parameter was found in June with 165 mg/L respectively. Usually, the value of this parameter is low in the rainy season and high in the dry season, and we can see such a result according to the value of rainfall in the above mentioned months. The hardness of water depends on the flow of water in the surface and underground. Waters in calcareous areas are harder than waters in granite or sandy areas. Hardness also varies over time. The hardness values in Fig. 7 shows that all samples were in the hard water category "between" (150-300). Due to the fact with increasing the total water hardness, the value of $IRWQI_{SC}$ index and consequently water quality decrease, therefore, the value of water quality in December was in the category of poor quality.

The amount of light scattered or absorbed in water or solution by suspended matter as it passes over a path is called water turbidity. Turbidity is caused by the presence of suspended solids in the water. As can be seen in Fig. 8, the turbidity of the river water in November was very high due to rainfall and muddy river water. And according to Fig. 8, it can be seen that heavy rainfall has increased the flow of the river and finally muddy and increased turbidity in November.

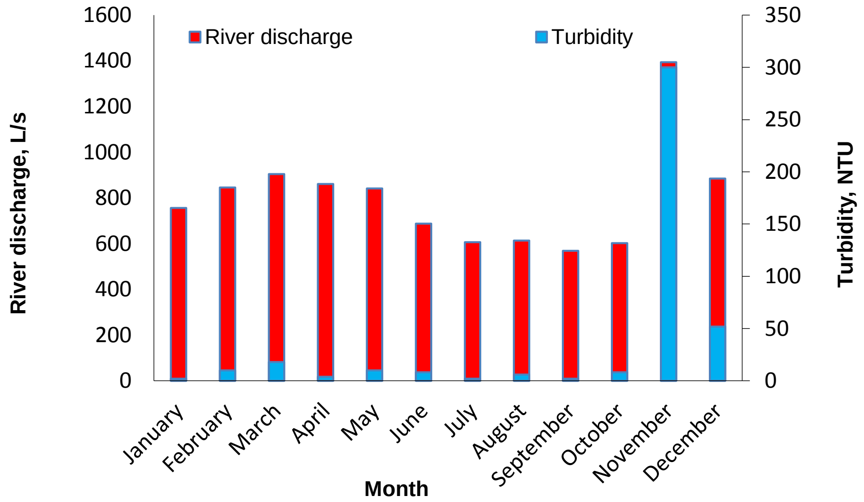

Fig. 8. Turbidity rate and River discharge in different months.

Table 4 shows the results of the quality index in the sampling station during the four seasons sampling period. The results showed that in spring, the highest index was related to May with a value of 32.47 and the lowest was related to April with a value of 27.83, which descriptively were in a relatively bad and bad condition respectively. In summer, the highest index was observed in August with a value of 32.17, which indicated the relatively poor water quality of the Golin River. Also, the lowest level of water quality index in summer was related to September with value 30.57 and the water situation in this month of the year was in a relatively bad range.

The study of Golin river water quality in autumn showed that the highest quality index was related to October with 31.99 and the lowest value was related to December with 27.36 which described in the categories relatively bad and bad respectively. Moreover In winter, based on the results presented in Table 4, the highest index number was observed in February and the lowest number in January with values of 27.59 and 27.29, with a very small difference and described in bad categories respectively.

The results obtained from the study of water quality of Golin River during one year showed that in general, the water of this river was in relatively bad condition in terms of $IRWQI_{SC}$ index in hot seasons and bad condition in cold seasons respectively. The results of the study of water quality of Pesikhan River based on $IRWQI_{SC}$ and NSFWQI indices by Shokohi and Modbari (2018) also showed that in summer the quality of the river was in a relatively bad category, which it was in line with the results of the present study.

The Statistical analyzes showed that the numerical mean of the $IRWQI_{SC}$ index was in a significant difference between cold and warm months of the year ($P \leq 0.05$). According to Fig. 9, it can be seen that the highest and lowest $IRWQI_{SC}$ index were related to September and January months, respectively. The index was affected by various factors, the most important of those factors were BOD_5, COD, DO, EC, NO_3^-, TH and PH. The $IRWQI_{SC}$ index was inversely related to different parameters including (BOD_5, COD, EC, NO_3^-, and TH) and it was directly related to the DO and PH parameters.

Table 4. Results of Golin river quality assessment based on IRWQIsc index in the sampling station.

Season	Month	Index rate	Descriptive equivalent
	April	27.83 [b]	Bad
Spring	May	32.47 [a]	Relatively bad
	June	31.74 [a]	Relatively bad
	July	31.61 [a]	Relatively bad
Summer	August	32.17 [a]	Relatively bad
	September	30.57 [a]	Relatively bad
	October	31.99 [a]	Relatively bad
autumn	November	27.44 [b]	Bad
	December	27.36 [b]	Bad
	January	27.29 [b]	Bad
winter	February	27.59 [b]	Bad
	March	27.41 [b]	Bad
Annual average		29.62	Bad

a , b: Statistical grouping according to Duncan's statistical index
Different letters show significant differences (P<0.05) between months

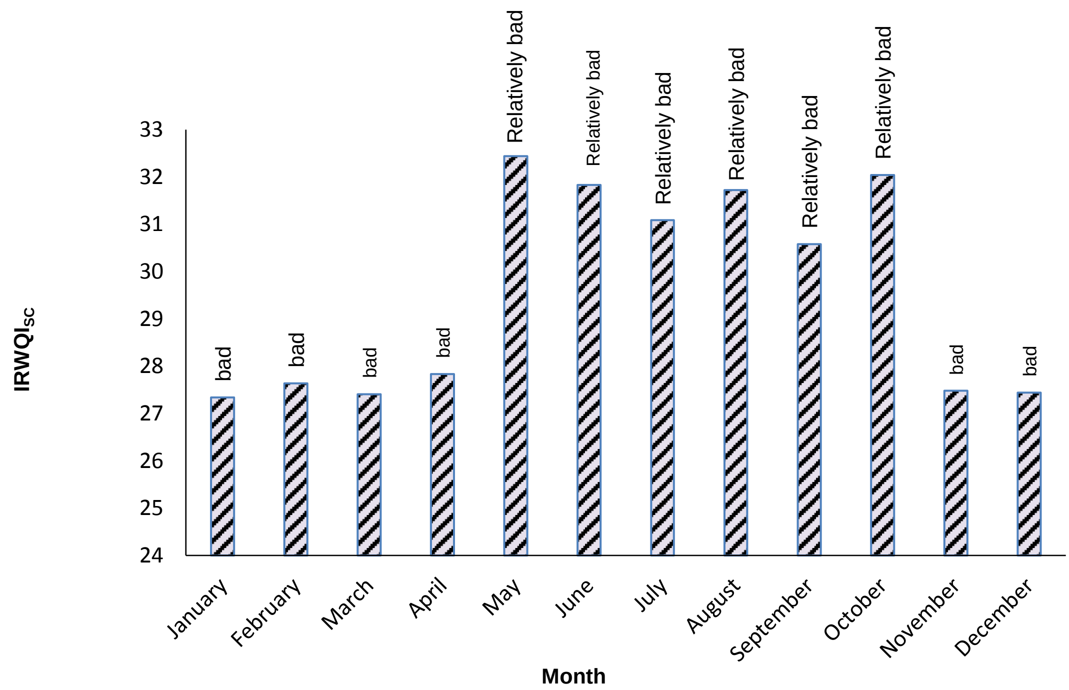

Fig. 9. The IRWQISC water quality index in different months (dissimilar letters on the level (P≤0.05) between different months).

4. Conclusions

The results obtained from the study of Golin River water quality during one year showed that in general, the water of this river was relatively bad and bad in terms of IRWQI$_{SC}$ index in hot and cold seasons respectively. Since the index was affected by different parameters (BOD5, COD, EC, NO3, TH, PH, PO4, NH3 and Turbidity), increasing the value of those parameters in autumn and winter by creating a negative impact on water quality caused the water of Golin river to be in poor quality category. During summer and spring seasons by reducing the value of those parameters the water quality situation was somewhat better and was in a relatively bad category. In general, according to the results presented from the annual average of the index numerical values, it was in poor quality category. One of the reasons for obtaining the mentioned results was the location of sampling station at the bottom of the river in the village of Najjar Golin, which shown all the pollution caused by agricultural, residential and livestock activities throw the river. Continuous monitoring, treatment of effluents from human activities, domestic wastewater and preventing their discharge into the river in an untreated manner can be suggest as a number of management strategies to improve the condition of the river and reduce pollution. Finally, it can be said that the results which presented in this study can be useful for different organization decision to perform their water related projects on Golin River.

Author Contributions

Houshang Ghamarnia: Supervisor, research design, review and control of results, correction, review and finalization of the article.
Zoleikha Palash: Sampling, testing and data collecting, calculations, analysis and statistical analysis of data, analysis and interpretation of information and results.
Meisam Palash: Editing and finalizing and translating the article in English.

Conflict of Interest

The authors declare no competing interests and non-financial competing interests.

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Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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